

FIRST QUARTERLY REPORT

CAVITATION STUDIES IN LIQUID HYDROGEN

by

T. T. Nagamoto, J. Hord, and R. V. Smith

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

September 30, 1964

CONTRACT NUMBER C-35560-A

Technical Management  
NASA Lewis Research Center  
Cleveland, Ohio  
W. R. Britsch

Cryogenics Division  
National Bureau of Standards  
Boulder, Colorado

FACILITY FORM 602

N 65-80544

ACCESSION NUMBER

1859739

(PAGES)

NASA CR OR TMX OR AD NUMBER

(CATEGORY)

(CODE)

(THRU)



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON 25, D.C.

IN REPLY REFER TO: ATSS-AC

MEMORANDUM

DEC 8 1964

TO : *RP/A. O. Trochler*

FROM : ATSS-AC/Contractor Reports Unit  
Scientific and Technical Information Division

SUBJECT: Request for document release

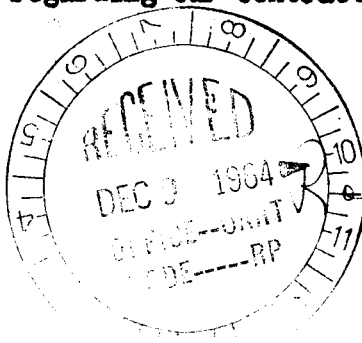
N 65-80544

The Scientific and Technical Information Division recognizes NASA Headquarters Program Offices' responsibility to recommend processing and distribution limitations on documents prepared under their auspices. In this regard, attached for your information and appropriate action is a "Document Release Form" for a NASA-sponsored document which we believe was prepared under your responsibility. It would be appreciated if you would complete the Document Release Form and return the original copy together with the document, if attached, to Code ATSS-AC so that we may process the document in accordance with your desires. In addition, you may feel this report is worthy of printing under NASA covers and being automatically distributed to the same distribution list as a NASA Technical Note in a similar subject area. If so, please note "under NASA covers" above your signature.

It is the desire of the Scientific and Technical Information Division to receive classified and unclassified scientific and technical documents generated by NASA activities automatically in order that we may place them under a centralized bibliographic control for subsequent retrieval and use as expeditiously as possible. In this regard, you may wish to consider granting a comprehensive authority to process on a routine basis any or all documents emanating from a specific program, project, or contract for which you are responsible. This office will be pleased to prepare, with your guidance, a memorandum of understanding containing your instructions regarding the release and processing, on a routine basis, reports prepared as a result of your contracts or projects. As a result of such an agreement the reports could be received and made available without our contacting your office on a recurring basis. We will be pleased to discuss such an arrangement with you at any time you so desire.

Thank you for your consideration in the release of the information attached, as well as your consideration to granting a "blanket" authorization. If you have any questions or comments regarding our contractor reports program, please let us know.

Attachment



*Robert L. Murphy*

# CAVITATION STUDIES IN LIQUID HYDROGEN

by T. T. Nagamoto, J. Hord, and R. V. Smith

Cryogenics Division - National Bureau of Standards, Boulder

## SUMMARY

This report describes the facility design, equipment procurement, planning, fabrication and assembly for this project.

## INTRODUCTION

The scope of work for this report is concerned with the preparation of the equipment and facility for determining the effects of cryogenic fluid properties and venturi configuration on the cavitation phenomena. This requires modification of existing facility and equipment on hand, design, procurement, and fabrication of necessary additional equipment. Also there are some components which require further investigation before the final decision can be made.

## BODY OF REPORT

The required revisions of existing drawings to accommodate the venturi test sections and related instrumentation stations together with necessary changes required for LOX compatability of the system are nearly finalized. The purchasing of materials of construction and required machine shop work are respectively 90% and 50% complete and assembly of the apparatus has commenced.

A new mock-up test section utilizing a high compression "O" ring design was fabricated and tested with positive results. No leakage was detected by a helium leak detector with 500 psi He pressure inside the test section and vacuum on the outside with the lucite and flange cooled to 76°K. A pair of stainless steel flanges utilizing the high compression "O"-ring seal design was fabricated and tested with positive results under the same conditions as mentioned above. This seal design will be used in the vacuum-jacketed liquid lines. Attached are memorandums concerning the results of the testing of these seals.

The two 265-gallon dewars are hydrostatically pressure checked, cold shocked with  $\text{LN}_2$  and a volume-height calibration was made with water. This room temperature calibration will be corrected to the temperature of the cryogenic fluid being tested.

After consideration of the use of a turbine meter to measure fluid flow, it was decided to use a venturi tube instead because of the large (3 1/2 inch) turbine meter required to measure the high  $\text{LH}_2$  flow (450 gpm). The venturi meter will be used in the higher flow range (upper two thirds) and liquid level point sensors will be used in conjunction with the volume height calibration of the supply dewar for the lower flow range. The precision of the flow measuring system will be within  $\pm 1\%$ .

Our tentative plans are to use the Wollensak FASTAX camera (8 mm - 16000 pps) for photographic coverage. A Tungsten filament (SUNGUN) continuous lamp will be used for either side or back illumination. A PHOTOSONICS (16 mm - 1000 pps - 25 micro-second exposure) camera is also available from another project.

Cavitation incipience will be sonically detected with a piezo-electric crystal coupled to a cathode-follower and oscilloscope. The crystal must be mounted on the test section in a fashion which will prevent signal decay due to low crystal temperature. Mounting details will be examined and the detection equipment will be optimized on a cavitating freon system prior to installation on the low temperature test piece.

# Memorandum

TO : Tom Nagamoto & J. Hord

DATE: Sept. 22, 1964

FROM : D. H. Weitzel

*D. H. Weitzel*

SUBJECT: Testing of Lucite to Aluminum Seal

The seal appears to be satisfactory. At 76 K with 500 psig He inside and vacuum outside the He leak detector showed no increase over the background reading. This indicates a leak rate of less than  $10^{-6}$  atm cc/sec.

The sequence of assembly and testing were as follows:

- (1) Assembled with .070 in cross section diam Buna N (Nitrile) rubber O-ring, Parker Co. size 2-33, Compound N 219-7. Measured hardness was 80 durometer.
- (2) Cross tightened the bolts (8 bolts, aluminum, 3/8 in diam, 16 threads per in) to a final torque of 50 in-lb. Used one Solon #5-L-5 compression washer, 17-7 PH ss under each nut.
- (3) Testing was as follows:

<u>Pressure</u>		<u>Temperature</u>
<u>Inside</u>	<u>Outside</u>	
a. vac	1 atm	room
b. vac	1 atm	76 K
c. 1 atm	vac	room
d. 1 atm	vac	76 K
e. 300 psig	vac	76 K
f. cycled between "d" and "e" several times		
g. vac	1 atm	room
h. vac	1 atm	76 K
i. 1 atm	vac	room
j. 1 atm	vac	76 K
k. 300 psig	vac	76 K
l. 500 psig	vac	76 K

- (4) There was no detectable leak during any of these tests. Thermal shock was severe, consisting of either (a) direct immersion into LN<sub>2</sub> or (b) continuous transfer of LN<sub>2</sub>, through a small transfer line, into Lucite cup, requiring about 10 min to fill. He pressure was introduced after LN<sub>2</sub> level dropped below seal.

# Memorandum

U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS  
BOULDER LABORATORIES  
BOULDER, COLORADO

TO : T. Nagamoto

DATE: October 20, 1964

FROM : D. Weitzel

*D. Weitzel*

SUBJECT: Test of Modified Weld Neck Flange for Cryogenic Seal

A standard 1-1/2 in. diam. weld neck flange was modified by machining a pair of mating steps on the sealing surfaces. Details are shown in the shop drawing. A 77 durometer Viton O-ring, .070 inch cross section was positioned with a sleight stretch around the O.D. of the male step. No lubrication of the O-ring was used.

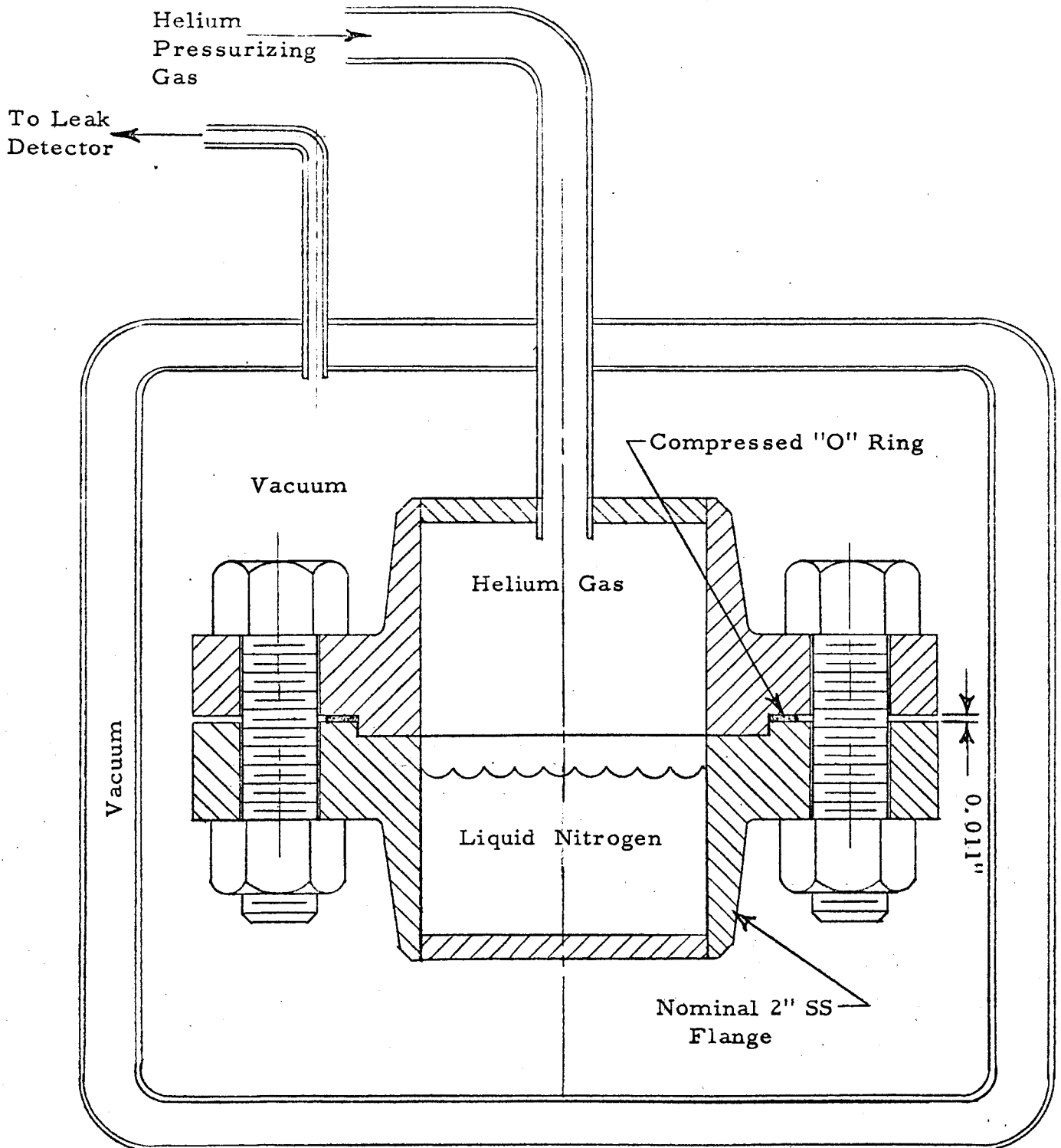
The flanges were fitted together and the O-ring compressed until the steps "bottomed out." This allowed a final thickness of .011 in. for the O-ring. Clamping force was derived from 40 to 50 ft-lb of torque on each of eight 1/2 in. steel bolts. Clearance at the outside edges of the flanges was .008 to .009 in., showing a small amount of flange flexure.

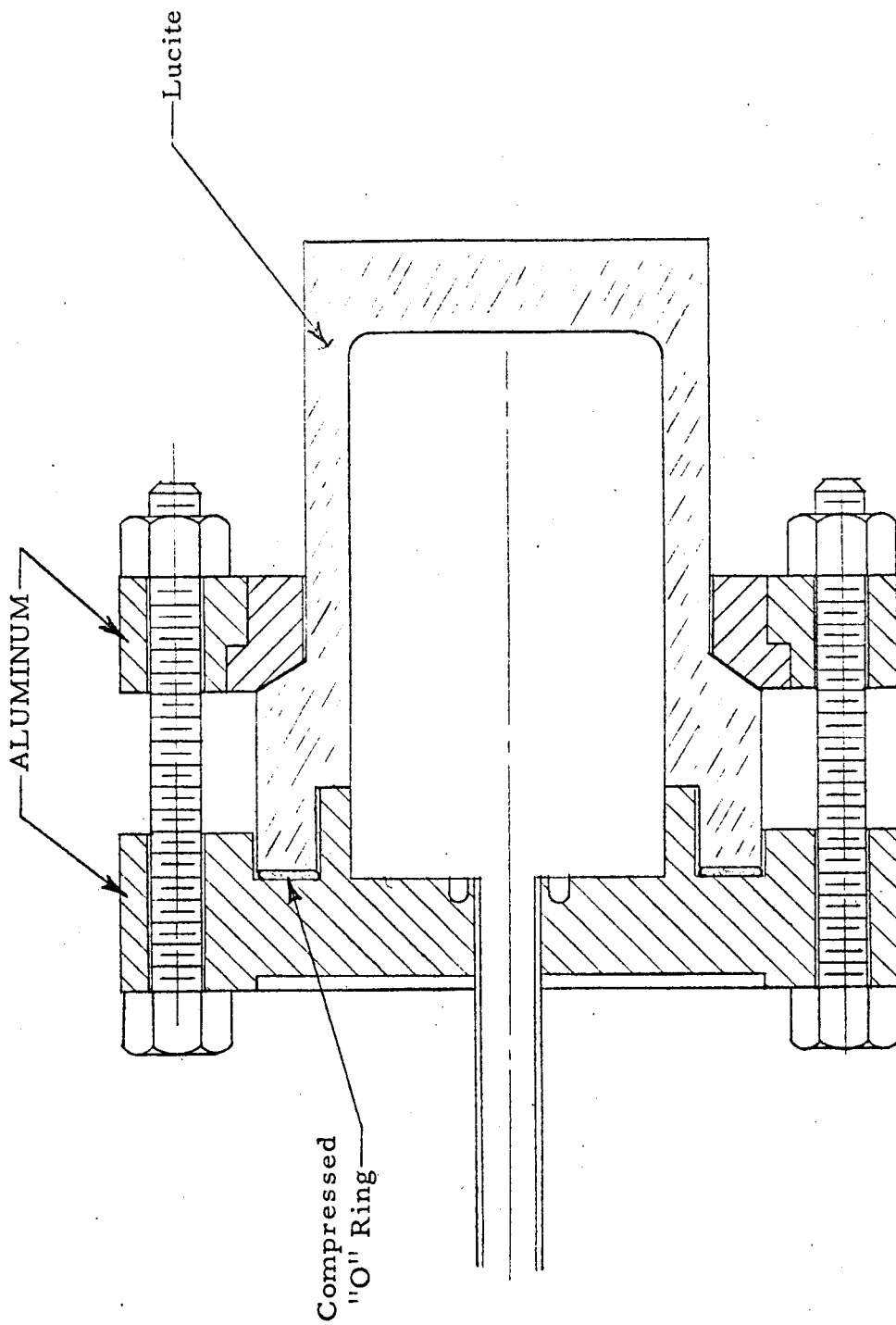
The assembled test section was placed in a vacuum tight container and tested as follows:

<u>Temp</u>	<u>He Pressure</u>
Room	500 psig
76 K	1 atm
76 K	500 psig
76 K	1 atm
Room	500 psig
76 K	1 atm
76 K	500 psig
76 K	1 atm
Intermediate	650 psig

Vacuum was maintained by a He leak detector throughout the testing. At no time was there any indication of leakage. Sensitivity of the instrument was sufficient to detect any leak in excess of  $10^{-6}$  atm cc per sec.

# SEAL TESTING APPARATUS





MOCK-UP TEST SECTION



# ESTIMATION OF PROJECT PLANS vs TIME

Contractor : NBS - CD  
Contract No: C-35560A

1964

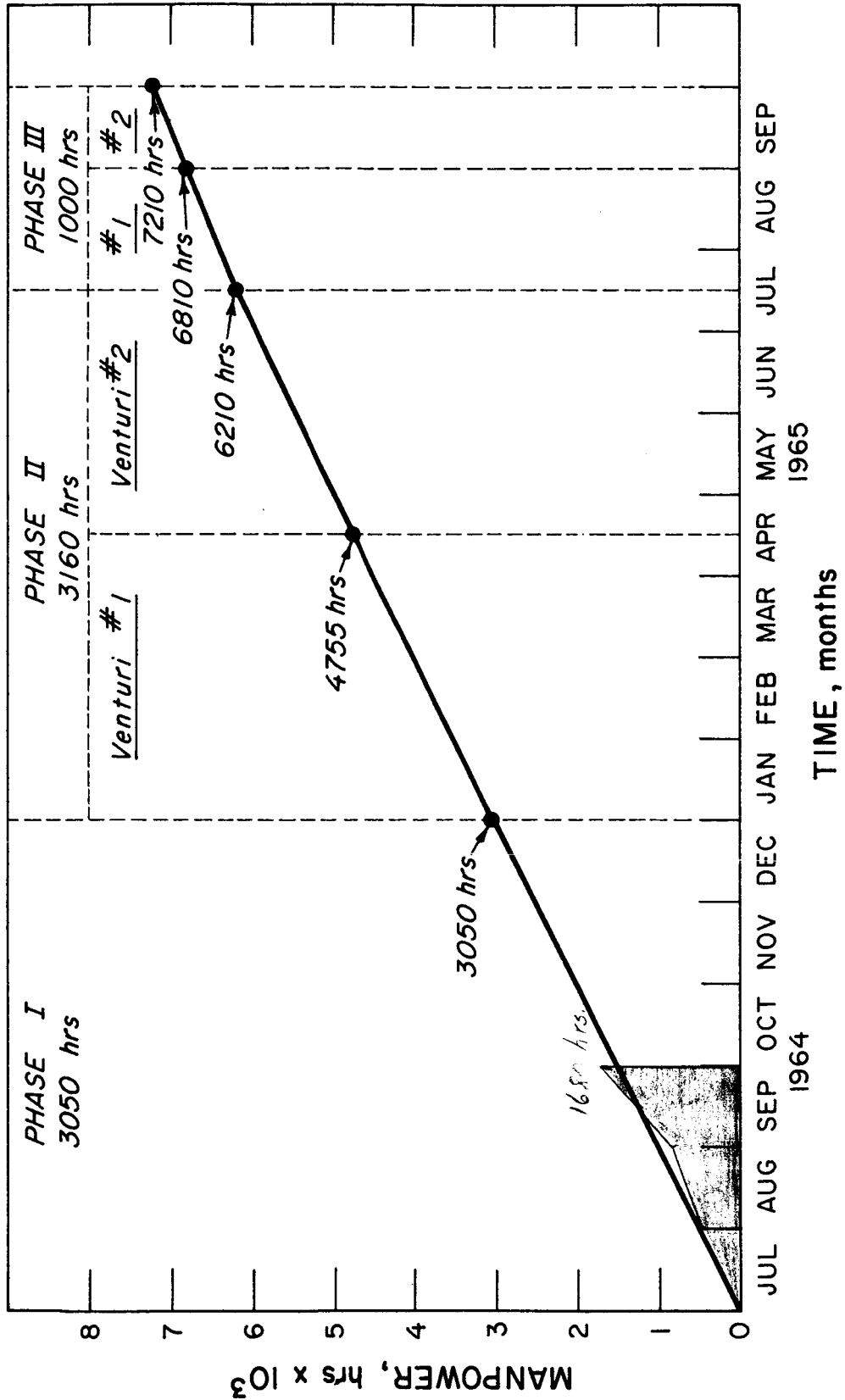
1965

PHASE	DESCRIPTION	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
I	<i>Procurement, fabrication, erection, and preliminary system check - out.</i>																		
II	<i>Cavitation test program using LN<sub>2</sub> and LH<sub>2</sub> as test fluid.</i>																		
III	<i>Cavitation test program using LOX as test fluid.</i>																		
IV	<i>Data Reporting.</i>																		

# ESTIMATION OF MANPOWER vs TIME

Contractor : NBS - CD

Contract No : C-35560A



# ESTIMATION OF DOLLARS vs TIME

Contractor : NBS - CD  
Contract No : C-35560-A

